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The Impacts of Microphysics and Planetary Boundary Layer Physics on Model Simulations of U.S. Deep South Summer Convection

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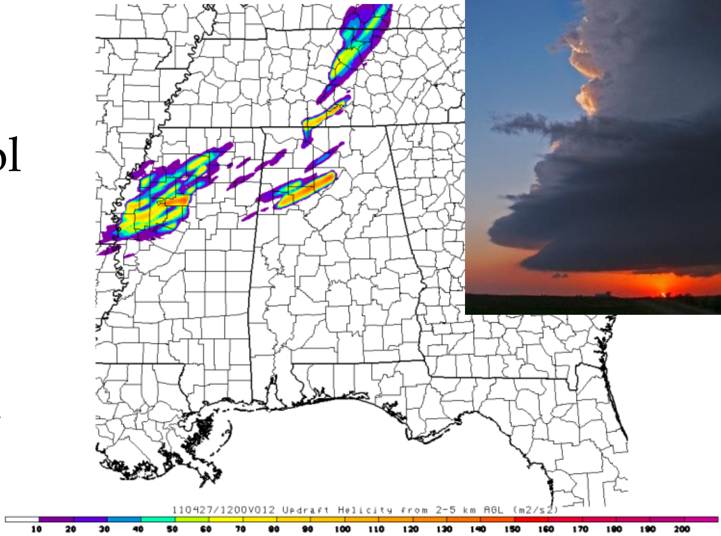
Introduction/Motivation

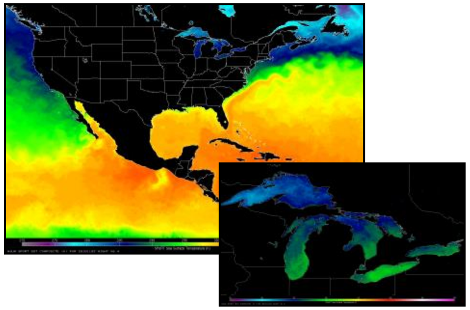
- Accurate forecasting of convection (timing, intensity, mode, location) is forecast challenge for regional/local scale modeling
  - WFOs cite this as main forecast challenge in their local modeling efforts when running the Weather Research and Forecasting (WRF) Environmental Modeling System (EMS) framework
  - SPoRT's data sets have been integrated into EMS and provide additional information on factors that contribute to convection in NWP models
- Composite results from a summer-long evaluation of forecasts with and without SPoRT data in 2012 revealed that both control and SPoRT forecasts exhibited a consistent under-prediction of precipitation coverage[1]
- Motivation for this work is to better understand sensitivities to microphysics and PBL schemes within WRF to optimally configure SR WFO EMS for forecasting CI with SPoRT data



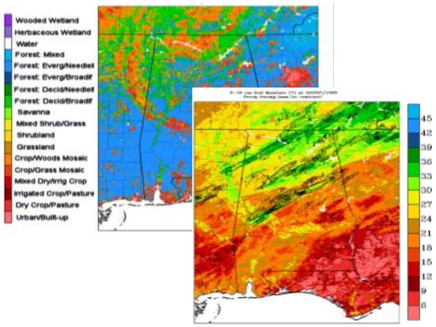
[1]Medlin et al. (2012); 26th SLS P121

Model Configuration

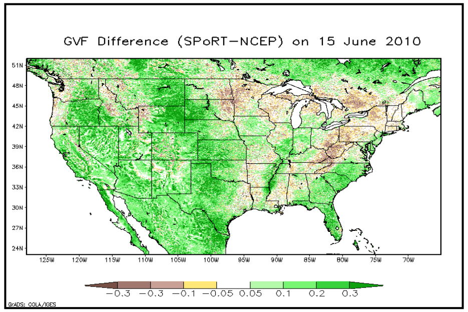
- Using WRF-ARW core (via EMS)
  - 9-km outer/3-km inner domains
  - 40 vertical levels
  - 54s timestep
  - Initalized at 0600 UTC; 24h forecast
  - Initial and boundary conditions from GFS personal tile (0.205°)
  - Convective parameterization: Kain-Fritsch (only on outer domain)
  - Longwave radiation: RRTM
  - Shortwave radiation: Dudhia
  - Microphysics and PBL vary for an 8 x 3 matrix of runs
- Performed a control (CNTL; above configuration) and SPoRT (above configuration + 3 datasets at the right)



- SPoRT SST Composite
  - 2-km resolution
  - Generated twice daily
  - Provides details that allow model to account for over-ocean fluxes and seabreeze forecasting

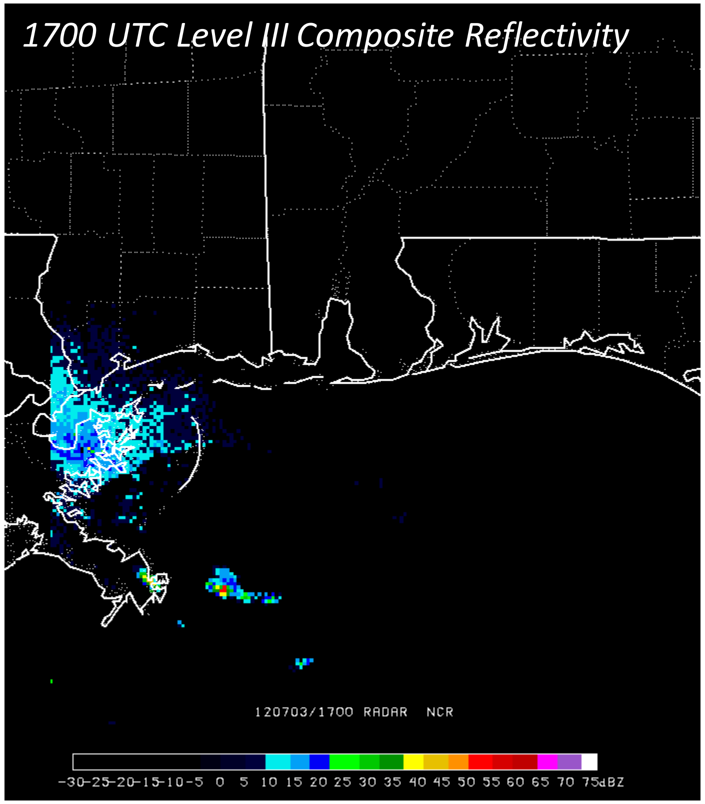


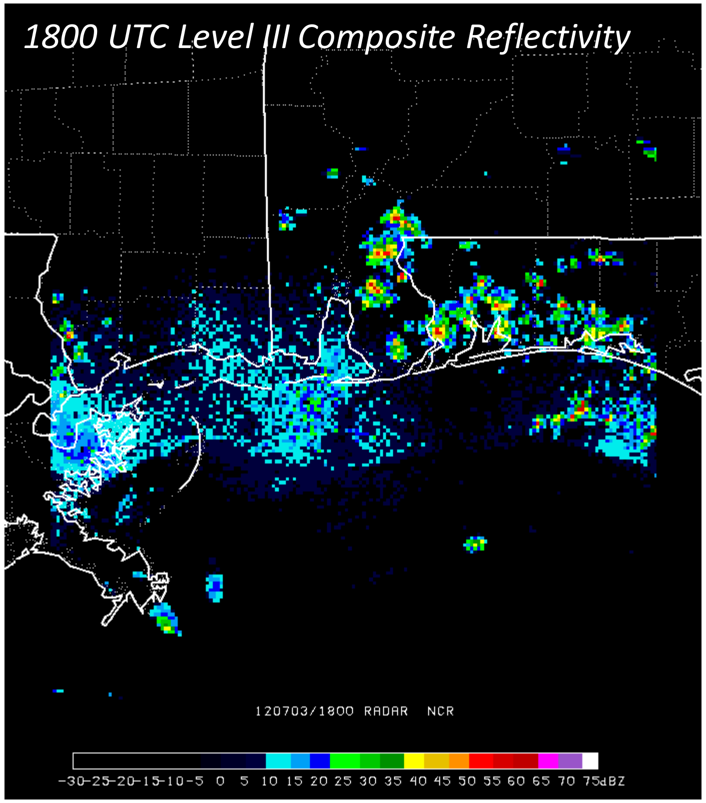
- LIS
  - 3-km resolution
  - Run once daily (available every 3 hours)
  - Uses precipitation data and vegetation to predict soil characteristics that shape energy fluxes for weakly-forced convection



- SPoRT MODIS GVFs
  - 1-km resolution
  - Generated once daily
  - Replaces coarse climatology to produce weather-of-the-day details that affect energy fluxes for weakly-forced convection

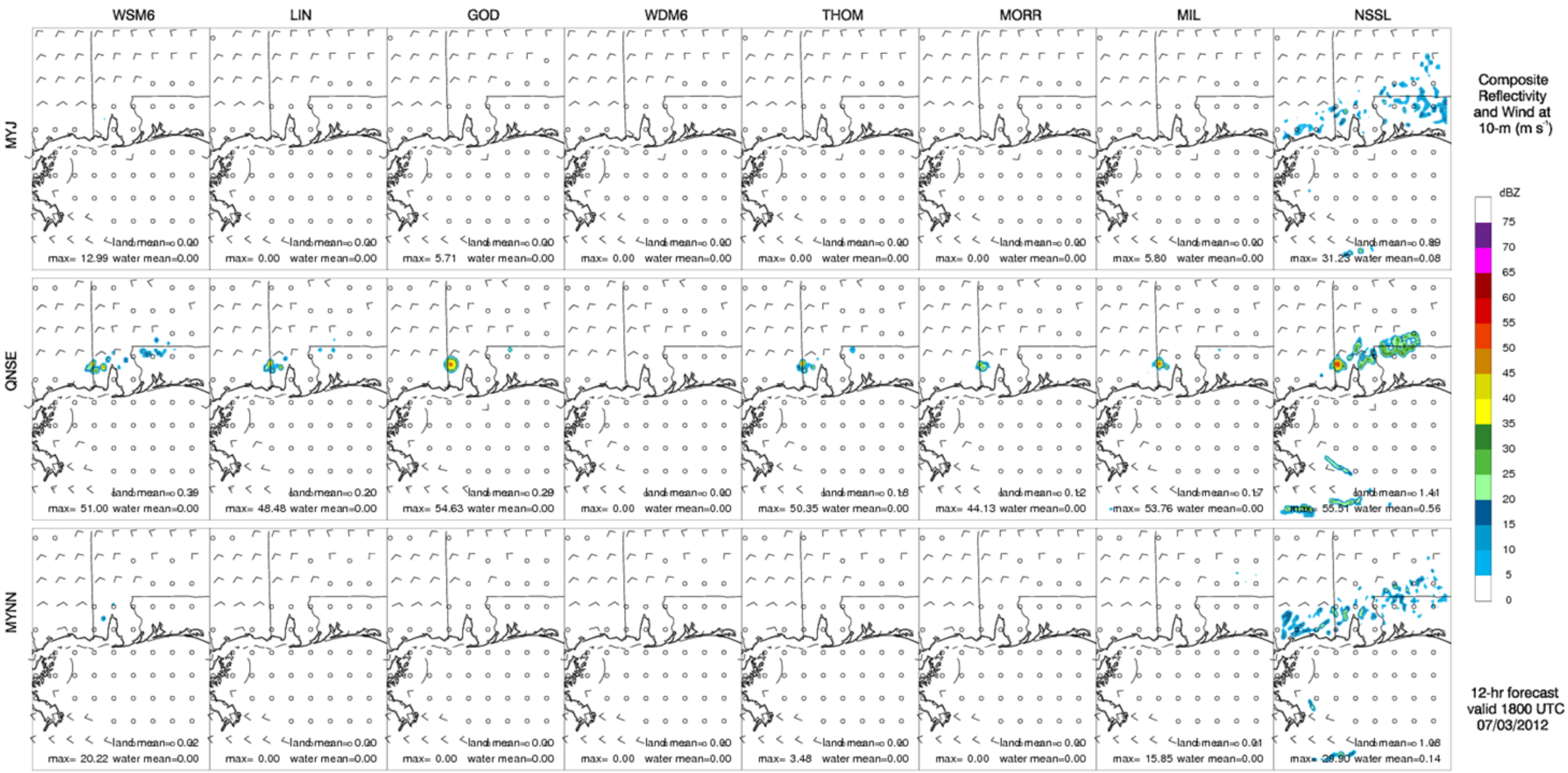
Mobile Case Study: 3 July 2012





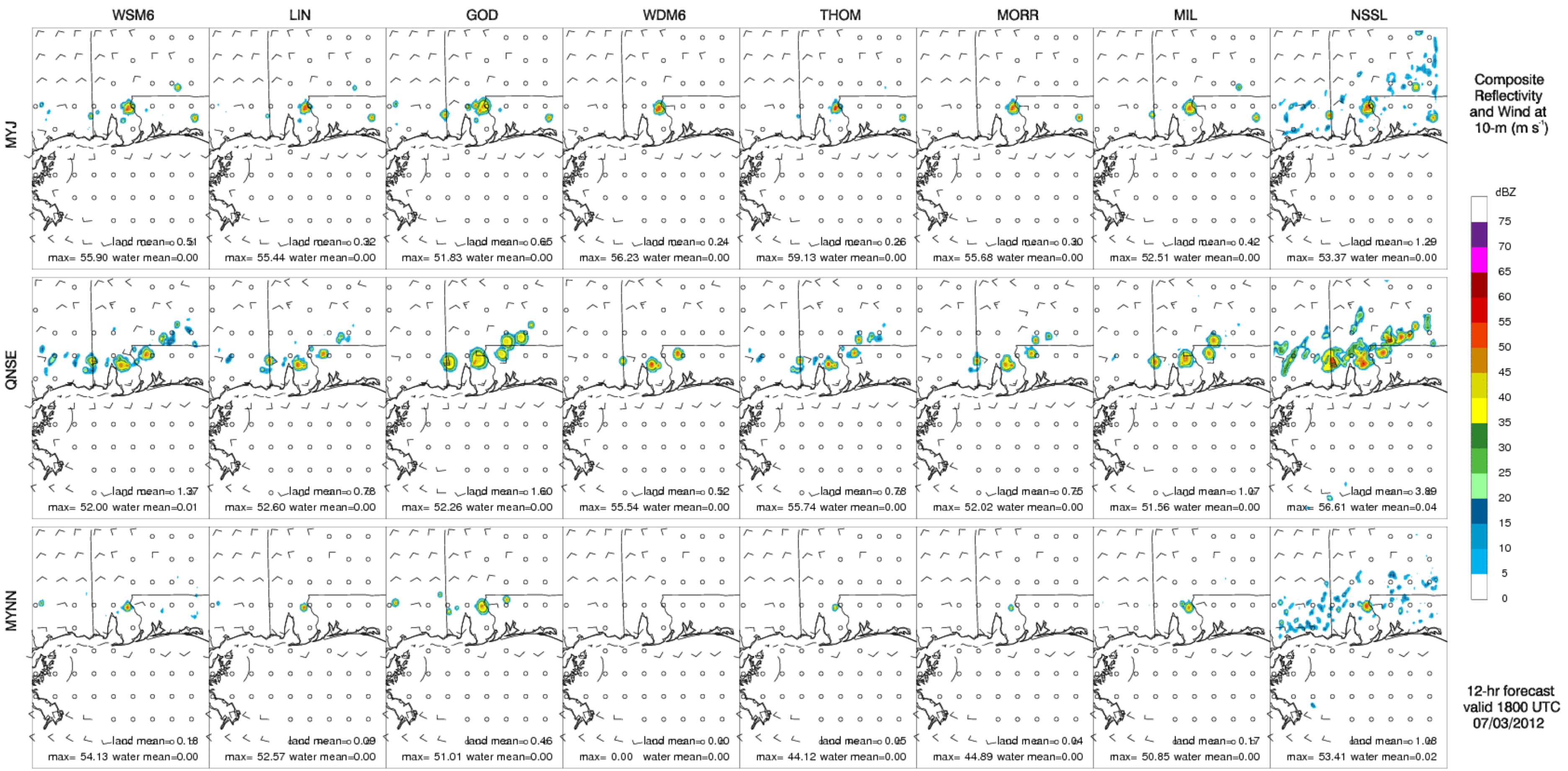
- Convective initiation associated with a seabreeze front occurred between 1700 and 1800 UTC across southern AL and western FL

CNTL Composite Reflectivity Matrix



- Most combinations do not capture the CI in magnitude, intensity, or location
- Seabreeze appears to be pushed too far inland (AL/FL border instead of FL coast)
- QNSE is most accurate PBL; NSSL is most accurate microphysics (this combo is best)
- For this example, it appears that selection of proper microphysics scheme is more important

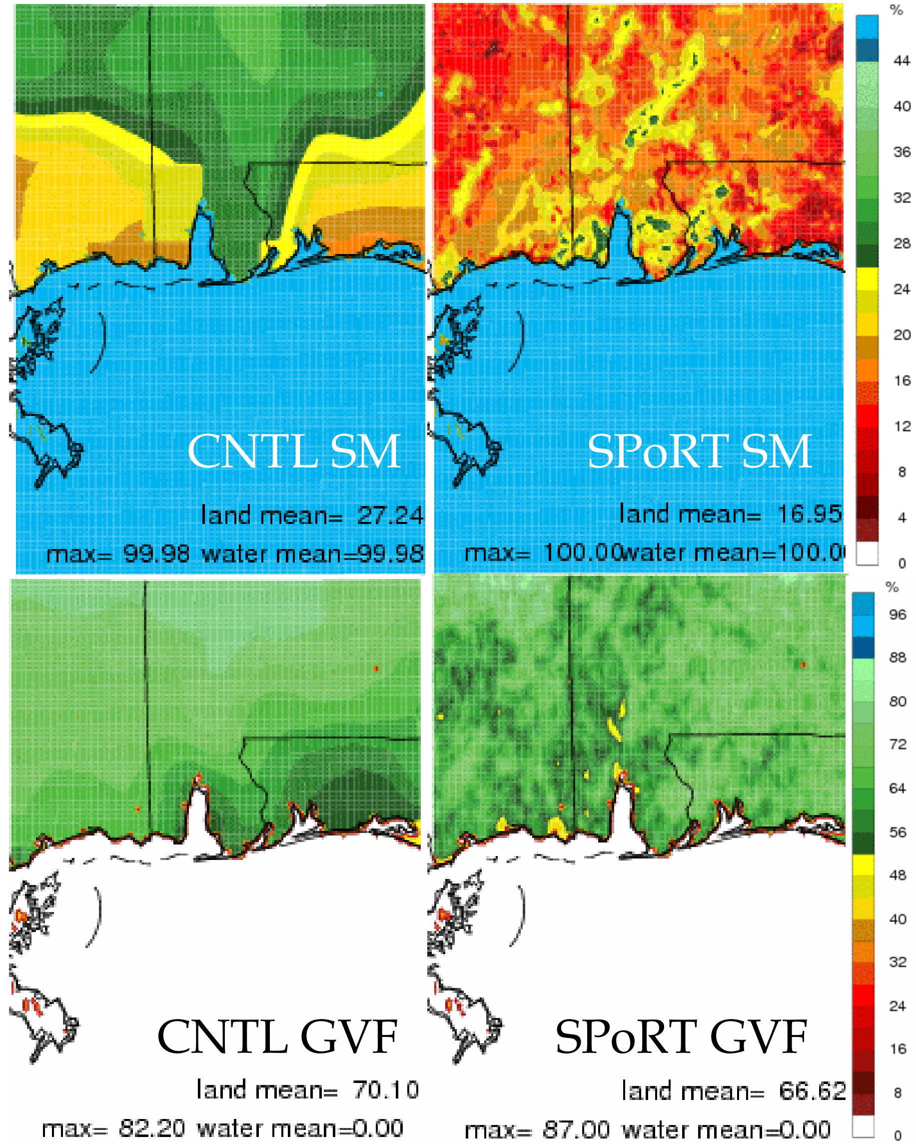
SPoRT Composite Reflectivity Matrix



- SPoRT data improves magnitude convection for all combinations
- Convection associated with seabreeze more to the south (more in line with observations) when SPoRT datasets are used for initialization compared to CNTL
- CI does appear in all 24 members, which is an improvement over CNTL

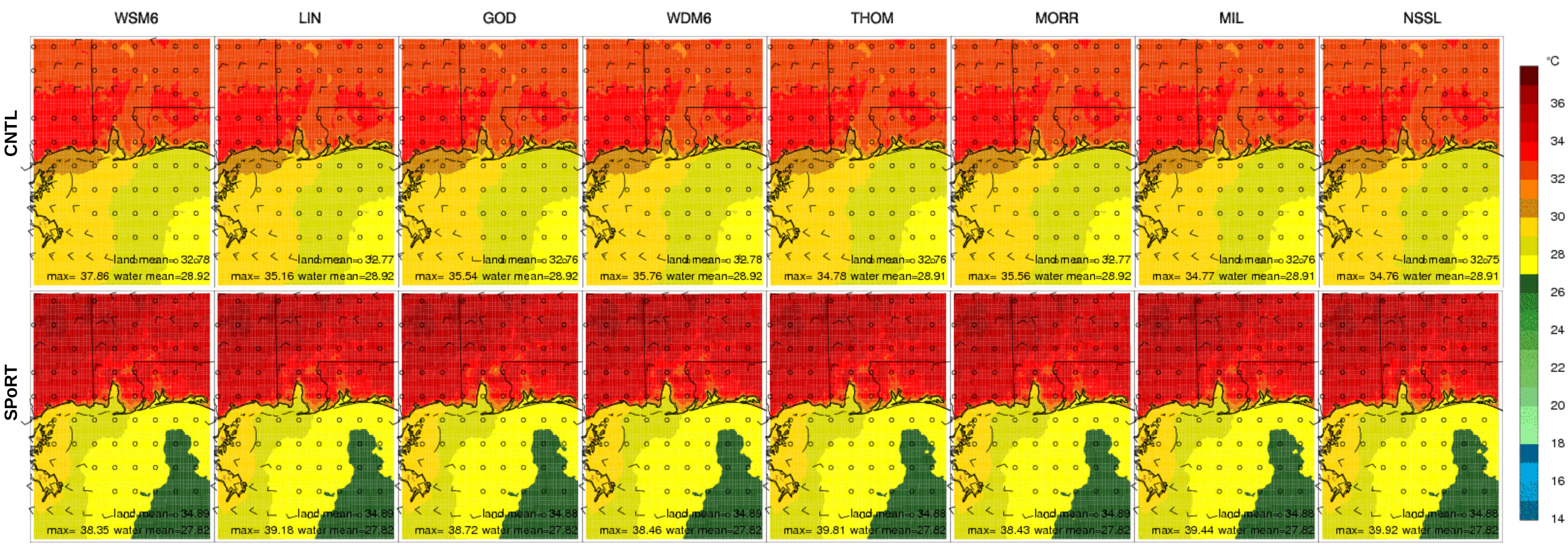
Evaluation of Land Surface

- Differences in land surface initialization appear to have played a major role in this event
- Land surface features are very smooth with the GFS initialization
- Soil moisture (SM) from LIS and SPoRT GVF provide greater detail of local features that can affect CI
- GFS soil moisture exhibited a moist bias during this time and the inclusion of the LIS data dried out the soils in that region by an average of 10%
- SPoRT GVF is slightly drier than CNTL especially in SW AL and SE MS



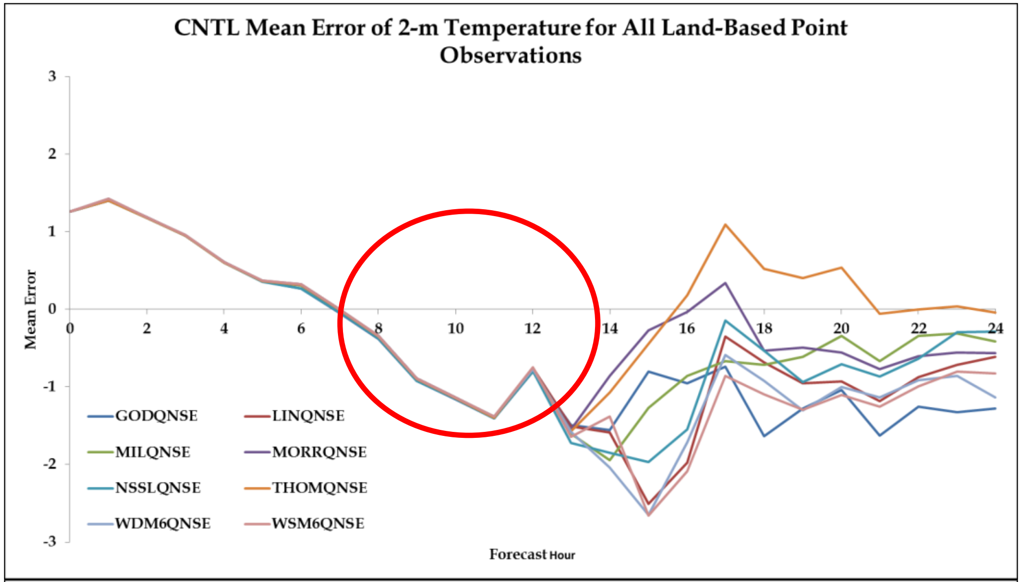
Evaluation of 2m Temperature

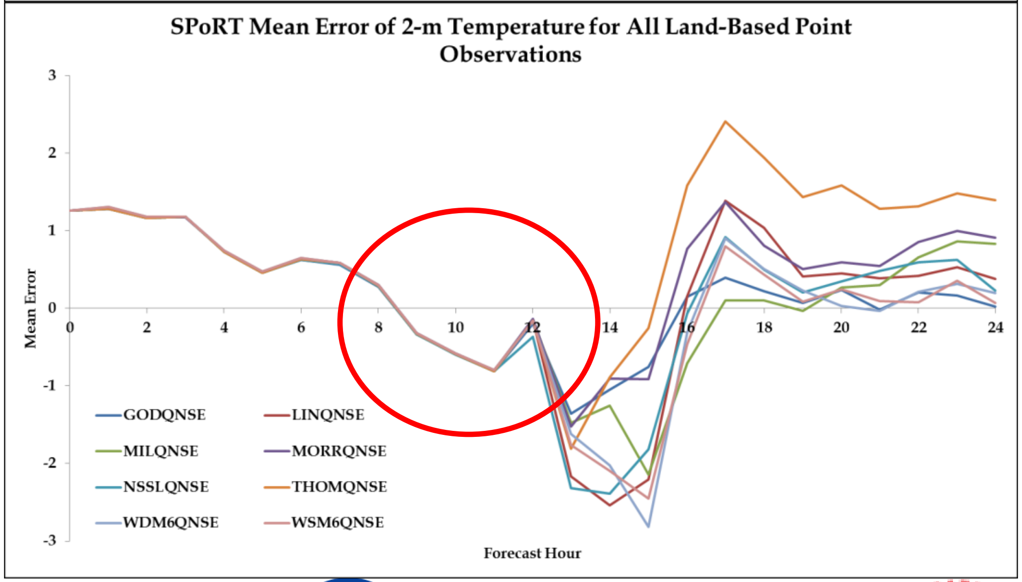
- Drier, less vegetated land surface in SPoRT forecasts results in faster and heating of the land surface
- SSTs over Gulf of Mexico also appear to be cooler in SPoRT run (2-m temperature over water is on average about 1°C cooler than in control)
- Gradient between cooler SSTs (SPoRT: 27.8°C; CNTL: 28.9°C) and warmer land surface (SPoRT: 34.9°C; CNTL: 32.8°C) likely results in a stronger seabreeze, which results in the enhanced convection



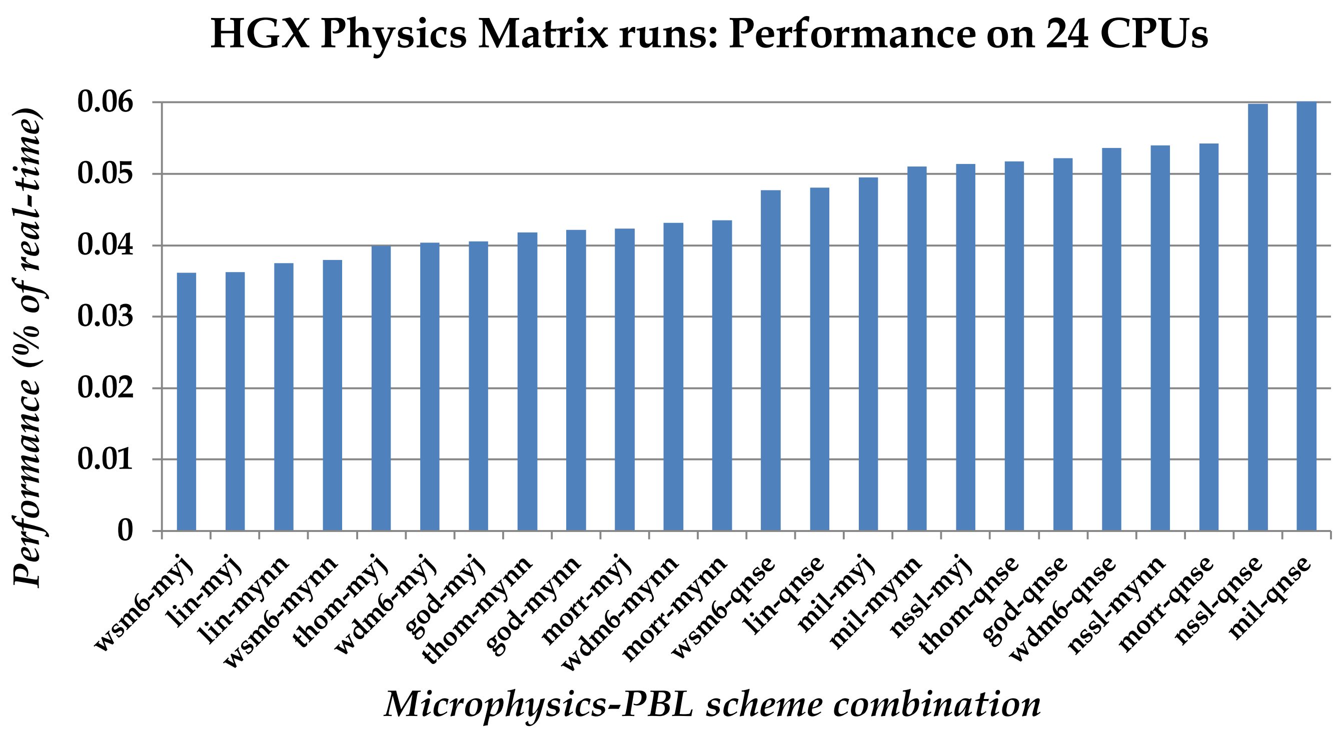
MET Verification

- Warmer 2-m temperatures in SPoRT runs (bottom graph) in the hours leading up to convection are closer to observations than the CNTL (top graph)
- Pre-convection results appear to be independent of microphysics
- Results from MYJ and MYNN PBL schemes have similar pre-convection clustering of mean error with the SPoRT experiment closer to the observations than the CNTL (not shown)





Time Constraints



- One consideration that must be taken when dealing with operational forecasts is the time constraints involved with forecast delivery
- Both HGX and MOB currently use WSM6/MYJ, which is computationally cheapest
- QNSE appears to be best PBL scheme, but is also most computationally expensive
- Each forecast office will need to determine based on their resources and time of forecast delivery which option is feasible

Summary/Future Work

- A control experiment initialized with large-scale land surface characteristics was compared to a SPoRT experiment using real-time SPoRT-LIS, MODIS GVF, and MODIS SSTs for a CI case study over Mobile
- Overall, SPoRT runs compare more favorably in timing, position, and intensity of initiated convection compared to CNTL
- Seabreeze more accurately represented in SPoRT run due to improved gradient in 2-m temperature
- Use of different land initialization datasets has larger impact on forecast than any differences between microphysics and/or PBL as evidenced by clumping of 2-m temperature
- Further evaluation on this case is needed to determine if u- and v-winds are improved with SPoRT datasets (further indication of seabreeze)
- Next step is to evaluate matrix results for 9 other cases to understand performance of different land surface initialization, microphysics, and PBL and generate cumulative statistics for more robust conclusions
- Results must be analyzed and compared to computational time constraints to then determine an optimal configuration to be used by WFOs for CI